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RELATIONS OF GRAVEL DEPOSITS IN THE NORTHERN PART OF GLACIAL LAKE CHARLES, MASSACHUSETTS.

INTRODUCTION.

AMONG the most impressive features of the glacial deposits in eastern Massachusetts is the great abundance of sandplains, which occur by scores in all the large valleys. The characteristic flat surfaces, lobate fronts, steep or kettled ice-contact slopes, and tributary eskers testify to the formation of the plains as deltas in glacial lakes, through transportation of the sand and gravel from the ice in which it was incorporated by powerful glacial streams flowing either upon or beneath the ice, and deposition in standing water along the glacier front. In association with the true sandplains are areas of kames, eskers, and other irregular deposits varying from mere patches of gravel to tracts several square miles in extent. At intervals during a period of two or three years the writer has had opportunity to study in detail the sands and gravels within a certain limited area, and takes this opportunity to give a few of his results, hoping they may throw some additional light upon the glacial-lacustrine history of the region.

LAKE CHARLES.

Lake Charles is the name given to the lake, or series of lakelets, which occupied the valley of the Charles River during the decay of the latest or Wisconsin ice-sheet.[1] The region drained by the river embraces portions of the counties of Suffolk, Norfolk, Worcester, and Middlesex, and is covered by the Boston, Framingham, Dedham, Franklin, and Blackstone topographic sheets. All portions of the valley are crowded by thick deposits of sand and gravel, among which flat sandplains are conspicuous, wave-cut shore lines have been occasionally noted, and on the east and south sides of the basin a number of well-defined lake outlets are known, each of which, as a rule, corresponds in level with the upper surfaces of a particular series of plains. Moreover, a study of the individual plains shows that a number of them often reach approximately to a common elevation, and, with few exceptions, they may be classified into one of several groups distinguished by their different levels. The elevations of the most abundant of these—not including those near sea-level—have been found to be approximately 150, 170, 200, and 270 feet in elevation, although local groups and isolated plains occasionally occur at intermediate levels. A fact thought to be of considerable significance is that plains having a common elevation are distributed over very wide areas. Deltas of the 170-foot series not only are known north and south of the Dover highlands and in the adjacent Neponset valley, but are very abundant across the divide of the Sudbury River in the vicinity of Cochituate, and even far down the valleys of the Sudbury and Concord Rivers. The widespread distribution of plains of the same general elevation at first appears to indicate the presence in the region of a large open body of water, which with successive retreats of the ice-margin, opening outlets for the lake at consecutive lower levels, allowed the water to fall repeatedly to the next stage below. Recent studies by Mr. M. L. Fuller in the Neponset basin indicate, however, that in that region there was no such simple sequence of events; and the present writer, working independently, finds evidence in Lake Charles indicating that here too the open lake hypothesis can be accepted only in part.

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[1] W. O. CROSBY AND A. W. GRABAU, *American Geologist*, Vol. XVII (1896), No. 2, pp. 128–30; F. G. CLAPP, "Geological History of the Charles River," *Technological Quarterly*, Vol. XIV (1901), No. 3, pp. 171–201; No. 4, pp. 255–69; and *American Geologist*, Vol. XXIX (1902), pp. 218–33.

DESCRIPTION OF THE REGION.

The location of the main region under consideration in the present paper is shown in Fig. 1. In a general way, it includes that portion of the Charles River basin lying south of the Boston & Albany Railroad in Newton and north of the Dedham and Dover highlands. More definitely, it is that part of the drainage basin of the present Charles River lying within that of the preglacial Charles. The portions of the valley lying north of the Boston & Albany Railroad, and those east of the Brookline and West Roxbury highlands, are not included, being within the limits of what has been designated Lake Shawmut—a glacial lake corresponding with later stages of the ice-retreat.

Topography.—A glance at the topographic map shows that the region may conveniently be divided into the following subdivisions: the Western highlands, the Dover and Dedham highlands, the Brookline and West Roxbury highlands, the Needham-Waltham valley, and the regions intermediate between uplands and lowlands, the last division consisting of the greater part of the towns of Newton, Needham, and Wellesley. Another feature of importance is the broad area of modified drift extending westward from Wellesley to the Sudbury River, and overlying the site of a broad preglacial

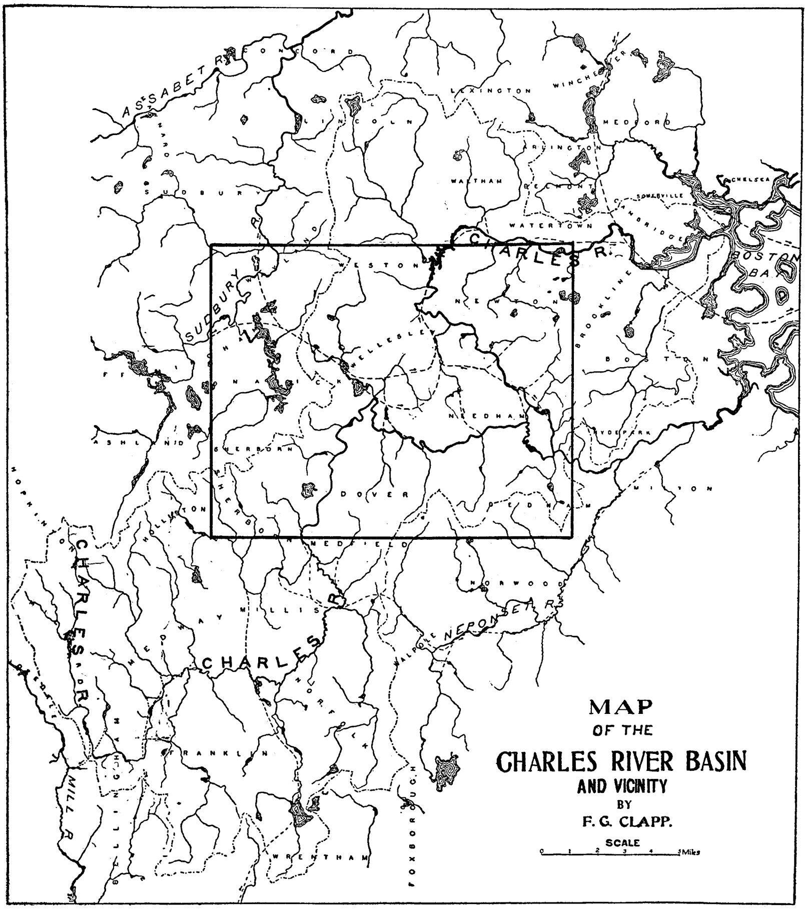

Fig. 1.

valley 100 feet or more below the present surface. This valley—the ancient outlet for the Sudbury valley drainage, is supposed to continue beneath Wellesley to the valley of Rosemary Brook, and thence northward to the present Charles River at Riverside. The broad marshy area east of Needham, in which the bed-rock surface is known to lie at a considerable depth below sea-level, was probably occupied by a tributary of the Charles which entered the main river just north of Highlandville. The valley between South Natick and Dedham contained no single preglacial stream. The largest unbroken upland region is the broad band extending westward from the Neponset River across Dedham, Westwood, Dover, and Sherborn, which in preglacial times separated the lowlands on the north and south into two distinct drainage systems, since united along the course of the Charles River.

DESCRIPTION OF THE DEPOSITS.

In a provisional classification we may recognize the following types of deposits as occurring in this portion of Lake Charles:

1. Flat-topped delta-fans—typical gravel plains—the level of which varies but a few feet in a single plain. These deltas almost invariably have a beautiful ice-contact slope, but the common lobate front may or may not be developed. For this class of deposits the common name of "sandplain" is used, although the plains considered consist largely of gravel.
2. Kettle plains, or deposits with a definite maximum elevation, but so broken up by kettle-holes as to have little semblance to plains. In origin, they differ from true sandplains only in having been formed among crowded ice-masses.
3. Eskers, or deposits of glacial streams. These are often conspicuously tributary to deltas.
4. Irregular deposits of gravel along the sides of valleys, usually consisting of great numbers of small hills or kames densely crowded together, for which the name "moraine-terrace" is sometimes used.
5. Kames—the name comprising all small, irregular hills of sand and gravel not included under (3) or (4).
6. Thin coatings or undulating deposits of gravel, apparently having no definite relations.

In the present study particular attention is given to the first three types.

SANDPLAINS.

Although in ascertaining the elevations of the plains the writer has not had opportunity to do any leveling, yet from the excellent contouring on the new Boston sheet, and in some instances by the aid of the older topographic maps, the approximate elevations have been interpreted in the field. Within the immediate area under consideration twenty-five typical plains have been studied, which are here named, with their approximate heights above tide. The distribution of the plains and their associated eskers is shown in Fig. 2.

1. Newtonville plain, 150 feet.
2. Newton Highlands plain, 150 feet.
3. Newton Center plain, 150 feet.
4. Winchester Hill plain, 150 feet.
5. Nahantan plain, 150 feet.
6. Cow Island plain, 140 feet.
7. West Roxbury plain, 140 feet.
8. Dedham Island plain, 150 feet.
9. Lower Falls plain, 150 feet.
10. Waban plain, 150 feet.
11. Wellesley plain, 150 feet.
12. Needham plain, 170 feet.
13. Birds Hill plain, 190 feet.
14. Dedham plain, 120 feet.
15. Wigwam plain, 120 feet.
16. Islington plain, 120 feet.
17. Pegan plain, 160 feet.
18. Noanet plain, 150 feet.
19. Cedar Hill plain, 270 feet.
20. South Natick plain, 120 feet.
21. Trout Brook plain, 100 feet.
22. Greendale plain, 100 feet.
23. Riverside plain, 60 feet.
24. Auburndale plain, 70 feet.
25. Newtonville plain No. 2, 80 feet.

Where the plains slope appreciably away from the ice-contact the elevation of the outer edge is taken, as representing most closely the true water-level. Most of them slope slightly, the difference in elevation sometimes amounting to as much as 20 feet, which makes it evident that plains having elevations given as 150 feet and others as 170 feet might have been formed as deltas in the same body of water. That such was probably *not* the case will be shown below.

In addition to the plains already enumerated, several exceptionally fine developments outside the Needham area have been visited in this connection. The most important of these are as follows:

26. North Wellesley plain, 170 feet.
27. Pickerel Pond plain, 170 feet.
28. Cochituate plain, 170 feet.
29. South Framingham plain, 170 feet.
30. Medfield Junction plain, 170 feet.

A comparison of the elevations of the thirty deltas shows that twelve of the number have an elevation of 140–50 feet, six of them of

170 feet, four of 120 feet, three of 60–80 feet, two of 100 feet, one of 160 feet, one of 190 feet, and one of 270 feet. All below 120 feet were deposited during the Lake Shawmut stages. The remaining twenty-five will be described somewhat in detail.

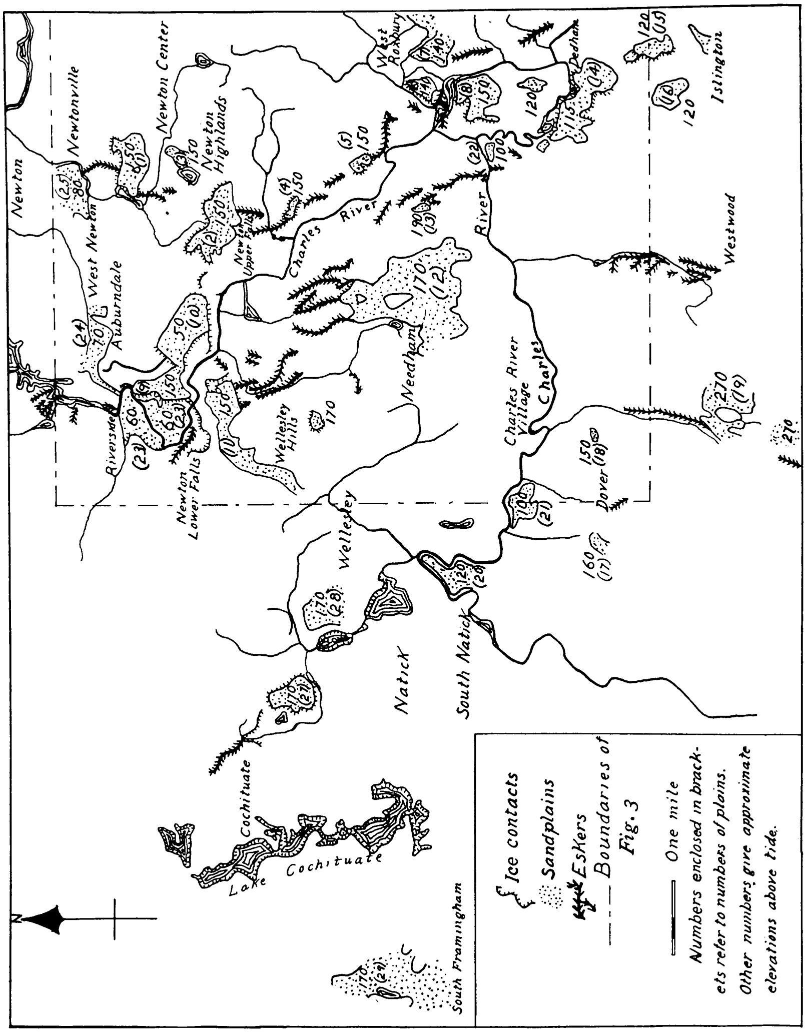

FIG. 2.—Distribution of principal eskers and sandplains. The dash line shows the boundary of Fig. 3.

NEWTONVILLE-WEST ROXBURY SANDPLAIN ESKER SYSTEM.

This series of deposits is situated entirely on the east side of the Charles River, and consists of a continuous series of alternating plains and eskers extending from the northern end of the Newtonville esker, one-half mile south of the Boston & Albany Railroad, across Newton to the frontal lobes of the Dedham Island and West Roxbury sandplains—a total distance of about six miles.

Newtonville esker and plain.—The classical delta known as the Newtonville sand plain, which has been described by Davis and Gulliver,[1] lies fully a mile south of the railroad, about half-way between Newtonville and Newton Center. It has an elevation of 150 feet, and averages fully three-fourths of a mile long and half a mile wide, occupying nearly the whole breadth of the valley of Laundry Brook. Several preglacial knobs rise through the plain, and to the east it rests against a low rock hill capped by a drumlin rising to an elevation of over 300 feet; on the north and west sides are characteristic ice-contact slopes; while a short stretch on the south forms good frontal lobes. Viewed from any standpoint, the deposit is a typical sand-delta, and well merits even more careful study than it has received. A large excavation on Commonwealth Avenue gives an unexcelled opportunity for viewing its internal structure.

The feeding stream of the delta is represented by the Newtonville esker, which first appears as it rises from beneath the lower and more recent plain at Newtonville, about three-fourths of a mile north of its junction with the sand plain. On both sides are large areas of densely crowded kames and kettles, with which the esker in places becomes somewhat confused.

Southwest of the plain there is also a small kame area. Unlike the southeast side, which has good frontal slopes, the southwest corner immediately south of Commonwealth Avenue breaks up into kames and kettles, which are composed of very coarse gravel, abounding in bowlders up to several feet in diameter. Within four hundred feet a further change takes place, by which the irregular hills become shaped into a typical esker, bounded on both sides by kames, and running in the direction of the Newton Highlands plain. Before reaching this there is a short break, due to a swamp, but the parallelism of the esker to the rock hill on the east, the close similarity between the levels of the two plains, and the apparently perfect topographic relationship indicate strongly that the esker stream was the feeder of the Newton Highlands delta.

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[1] W. M. Davis, "The Subglacial Origin of Certain Eskers," *Proc. B. S. N. H.* Vol. XXV (1892), pp. 477–99; F. P. Gulliver, "The Newtonville Sand Plain," Journal of Geology, Vol. I (1893), pp. 803–12.

Newton Highlands plain.—This plain, somewhat irregular in shape, extends a little over a mile in an east-and-west direction, and half a mile in its greatest breadth north and south. Like the Newtonville plain, it is bounded on the east by a rock hill, has ice-contact slopes on the north and northwest, and frontal lobes on the south; but the ice-contact in this case differs in character from the other by being extremely irregular, and in places much broken up by kettles. On the southwest the fore-sets run against the rock hill south of Eliot Station; on the north and south it is bounded mainly by low, swampy areas. It is for the most part a typical sandplain.

Cook Street esker.—The most interesting feature of the Newton Highlands plain is on the south side, near the Cook Street junction of the New York, New Haven & Hartford with the Boston & Albany Railroad. At this point a small knob of conglomerate rises above the glacial drift, and towards the north and east the fore-sets are broken and irregular, indicating the presence of ice here at the time of their deposition. Directly east of the conglomerate knob and south of Cook Street is a low esker running southward out of the sandplain. Beyond the first road it rises to a height of 30 feet or more above the swamp, and farther south widens to a breadth of at least 500 feet; but within 2,000 feet ends abruptly at a small brook. As this somewhat peculiar esker has been extensively excavated, its internal structure can be easily studied. The south end being in itself something of a delta, the main stream which formed it was probably not *directly* tributary to any plain.

Winchester Hill eskers and plain.—A few hundred feet to the west, however, and holding very definite relations to the small plain west of Winchester Hill, is another esker. Starting half-way up the side of the rock hill south of Eliot Station, it descends fully 40 feet. becoming at once a good-sized ridge, crosses the swamp to the kame field west of Highland Avenue, with which it soon becomes confused, and joins the sandplain at its northwest corner.

The Winchester Hill plain is comparatively small, hardly one-eighth the size of the Newtonville plain, although topographically its relations are somewhat similar; it is bounded on the east by a drumlin, the remaining three sides being free. Unlike the deltas already described, this plain has no frontal lobes, being surrounded on the north, west, and south by ice-contacts. Both to the south and west are extensive areas of kames and moraine-terrace.

Nahantan plain.—Lying a mile and a half southeast of Winchester Hill, in the midst of a large kame field, is a plain having the same approximate maximum elevation as the surrounding kames and of the associated esker. In extent of isolation it goes a step beyond the Winchester plain, as its surface does not rest at any point against rock or till, and it is entirely surrounded by ice-contacts and kames. As the slope of the Brookline highlands is not over 1,000 feet distant, it is likely that rock exists only a short distance below the surface, and the plain occupies as truly a marginal position as the others mentioned. In the area between this and the Winchester plain are two eskers, which, while they have not been observed to run directly into either plain, are supposed from their positions to mark the streams which carried the water southward between the two lakelets.

The esker running out of the Nahantan plain is better defined in its relations than the ridges similarly situated with reference to the preceding deposits. It quickly attains its individuality, and borders the kame area for nearly half a mile before finally disappearing below the Charles River meadows. One feature well worthy of special note occurs just south of the plain, where there is an enlargement of the esker barely 200 feet across, yet having all the characteristic structural features of the larger plains. South of the terminus of this esker the relations of the eskers of the series are not well defined. Short ridges appear above the flood-plain west and north of Cow Island, and continue from near Spring Street southeastward, crossing Washington Street on the boundary line between Boston and Dedham, beyond which no attempt has been made to trace them. At the southern point of Cow Island is a good junction of the main esker with a ridge which crosses the river from the south.

Cow Island, West Roxbury, and Dedham Island plains.—The elevations of the first two of these are indicated by the map as about 10 feet lower than the other plains of the system. This discrepancy may be real, but is more probably due to difficulty of interpreting the contours on a map of the published scale. In either case, it is believed that these three plains are of the same height, and were controlled by the level of a single body of water. They are all bounded on the west by steep and irregular ice-contacts, and the West Roxbury and Dedham Island plains rest visibly against preglacial knobs of land. With the Cow Island plain, on the contrary, no till nor rock can be found associated, and several wells drilled at the pumping station on the southeast side of Cow Island prove that the drift is here very thick. In one instance 90 feet of gravel was penetrated before reaching bed-rock.

Conclusions and discussion.—From the foregoing description several characteristics common to the deposits may be formulated:

1. The plains are nearly always marginal—deposited about knobs of rock or till. Conversely, most of the preglacial prominences rising above the valley floor have glacial deposits associated with them. This is probably partly due to the natural sinking of the decaying ice masses into the valleys, and in part to the principle that the heat reflected from rock masses accelerates the melting of the ice immediately surrounding them, forming hundreds of small marginal lakelets, throughout the decaying zone of the ice-sheet.

2. The plains without exception have a definite ice-contact slope, which in several instances entirely surrounds them, except on the sides which are bounded by higher land. This feature indicates that some of the lakelets became entirely filled by gravel, forcing further deposits to accumulate in quantity along the channels of glacial streams or in superglacial lakelets.

3. Where typically developed, the deltas are associated with feeding eskers on the north, and with effluent eskers on the south. Such a relation can only mean that the glacial lakes, like bodies of water on the present land surface, had both inflowing and outflowing streams, the latter carrying off the surplus water and providing a transporting and depositing agent for the excess of gravel. This is in accordance with what has been observed on the Malaspina glacier.[1] The controversy in regard to the superglacial or subglacial origin of eskers will not be entered here, but the writer believes there is evidence that eskers of both classes exist in the region, and that

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[1] I. C. Russell, "Expedition to Mt. St. Elias, Alaska," *National Geographical Magazine*, Vol. III, pp. 106–8.

by careful study of the individual cases their differences in origin can be detected.

4. The elevation of all the plains of the system is very nearly or quite uniform, at about 150 feet above tide. Thus, notwithstanding the supposition that there can have been no large open lake in the region, there was certainly some connection between the lakelets adequate to maintain the water at a common level. The remnants of the decaying ice-sheet consisted of stagnant valley-blocks much broken up, the whole mass saturated with water, which was maintained at a uniform level consequent on some factor outside the Needham area. Into this basin were discharged torrents of water, which carried the gravels and deposited them upon, beneath, and between the ice-masses. This view is satisfied both by the superglacial and subglacial theories of eskers, and further corroborates the supposition that in this area there are examples of both classes.

As the difference in elevation between the different plains of the series can not be more than a few feet, it is evident that in the waters of the lakelets themselves or below their level there can have been but little current. Notwithstanding this, it is known that water-worn bowlders of considerable size are abundant in many of the eskers and associated deposits, indicating a very powerful current. The most probable explanation, already alluded to, is that to the main superglacial or subglacial rivers were tributary many side streams which discharged into them from higher levels on the ice or surrounding land. The extensive kames and moraine-terraces are best explained, as shown by Fuller in the case of Lake Neponset, by supposing them to have been deposited upon masses of ice sometimes of considerable thickness, having a front sloping outward beneath the lacustrine waters.

The probable conditions existing during this stage are indicated in Fig. 3, in which the lakelets are represented by the dotted portions and the stagnant remnants of the ice-sheet by shading. The regions covered by a combination of these patterns usually correspond in position with large areas of moraine-terrace, and were at this time ice-tongues overlain by considerable depths of water, in which the superglacial and subglacial gravels were deposited. Glacial streams, so far as traceable, are shown by heavy black lines.

Their most striking feature is that they are conspicuously divided into two series, one following in a general way each side of the main valley and known to have connected with the other only at a single point. It is probable, however, that there were other connections which have not been preserved in the deposits. A second noticeable feature in the eastern series is the confluence at the Winchester Hill lakelet of two rivers, both of which have been traced for some dis-

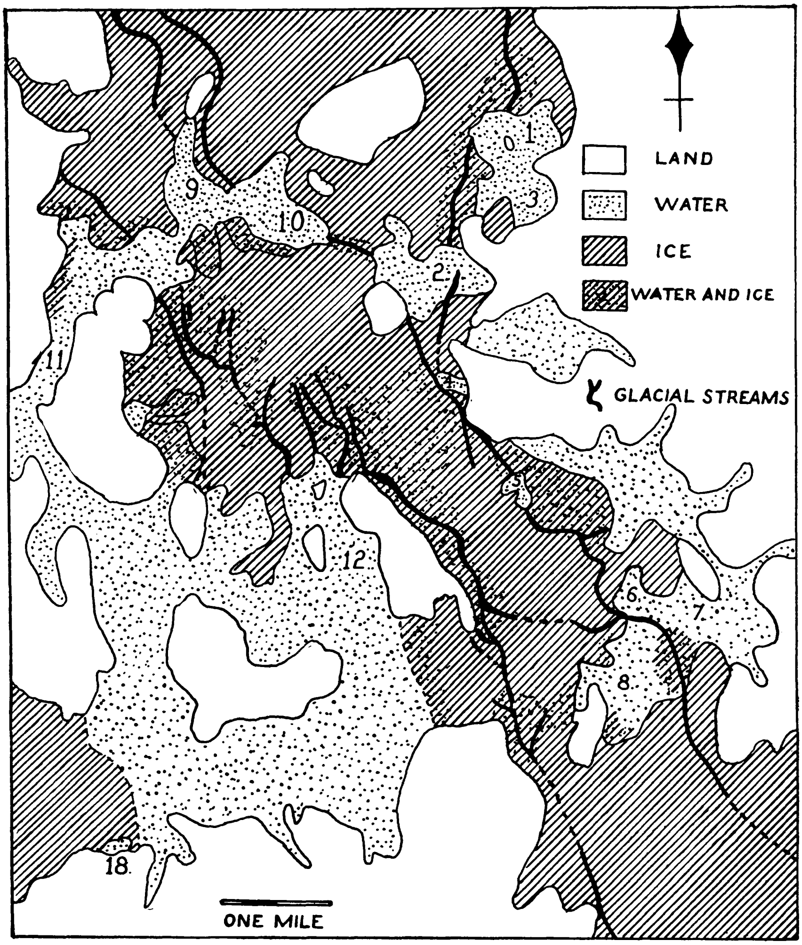

FIG. 3.—Probable conditions during the 140–170-foot stage of the glacial lakelets. (Numbers show locations of plains, and correspond with list given in the text.)

tance outside the map, and were apparently the only main streams draining the triangular area which they include.

THE NEEDHAM-FRAMINGHAM SYSTEM OF PLAINS.

For convenience of discussion this designation is applied to the group of plains lying between Needham and Framingham, having, in addition to a common elevation of approximately 170 feet, most of the characteristics of the preceding group. These deposits cover an area beside which the Newtonville-West Roxbury area appears insignificant; yet, as the writer has had little opportunity to study them in detail, they will be dismissed with a few remarks. Belonging to the group are at least six plains—the Framingham, Cochituate, Pickerel Pond, North Wellesley, and Needham plains. All have good ice-contact slopes, most of them on certain sides only; but one plain, that lying east of Pickerel Pond between Wellesley and Cochituate, is entirely surrounded by characteristic steep and kettled slopes. This plain, like that forming Cow Island, is the only member of its group not resting against the rock sides of the valley, and, like Cow Island, is supposed to overlie a buried preglacial gorge.

The most conspicuous topographic characteristic of this region is the abundance of kettle-holes, often occupied by ponds. Lake Cochituate, Dudley, Pickerel, Mud, Jennings', and Morse's ponds and Lake Waban are all kettle-ponds, overlying the course of the preglacial Charles River. Between, around, and upon the ice-blocks gravels were deposited, their mode of origin being demonstrated by their kettled character. The proportionate area of kames to kettles is much larger than in the deposits farther east, and the kettles are more isolated. Plains having in general the same elevation extend far down the valleys of the Sudbury and Concord Rivers; thus emphasizing the suggestion that in the Sudbury valley there were at that time fairly open bodies of water.

Needham plain.—This is the largest and most typical plain in the group. Hemmed in on east and west by rock hills, it is bounded on the north by a deep preglacial valley, in which the ice lingered and gave rise to deep kettles, extensive moraine-terraces, kames, and eskers. Three or more eskers, with relations suggesting a superglacial mode of origin, enter the plain from the north. Its southern side shows a beautiful lobate front, which, together with the absence of kettles and the scarcity of modified drift immediately to the south, indicates that in that direction was an open lakelet three to four miles in extent. The overflowing water, reinforced by the drainage from an extensive area to the west, found its outlet eastward through a large superglacial or marginal stream.

Lower Falls, Wellesley Hills, and Waban plains.—These are all about 150 feet in elevation, and the first two originally formed a single plain. Extending in an irregular line from near Rice Crossing north of Wellesley Hills to Newton Lower Falls, and thence to the high morainic hills east of Riverside, is a kettled and kamey ice-contact nearly three miles in length. Large kettles south and east of the Lower Falls indicate that the glacier to the north was almost connected with the decaying ice-blocks on the southeast side of the plain; but that it was not quite continuous is indicated by consideration of the fact that the slopes on both sides of the river are erosion slopes, in which artificial excavations show nearly horizontal stratification, probably once continuous across the valley. The Waban plain, lying closely adjacent to the Lower Falls plain on the east, was formed by the Auburndale esker stream.[1] It is bounded on the north and south by ice-contacts, is much broken up by kettle-holes, and might properly have been classified with the Newtonville-West Roxbury group, with which it is closely connected.

Other plains of the series.—In the valleys east and west of Dover are two or more small plains at approximately the same elevation, which are shown by ice-contacts on their valley sides to be deposits of small marginal embayments. Plains of the Newtonville-West Roxbury type occur in the Medfield-Medway basin of the Charles River, and also in the Neponset valley. The uniformity of elevation over such a wide area strongly suggests dependence upon some lake-outlet east of the Neponset valley. No systematic search for such an eastern outlet has been made in the field, but it is known that in the southern watersheds of the Charles and Neponset Rivers there is no pass lower than 200 feet above tide.

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[1] J. B. WOODWORTH, "Some Typical Eskers of Southern New England," *Proceedings of the Boston Society of Natural History*, Vol. XXVI, pp. 197–220; W. M. DAVIS, "The Subglacial Origin of Certain Eskers," *ibid.*, Vol. XXV, pp. 477–99.

The perfect ice-contact slope along the Boston & Albany Railroad east of Wellesley Hills, together with the absence of any flat-topped deposits rising higher than 90 feet, throughout the area to the northward, and likewise from the entire region east of the Brookline and West Roxbury highlands, proves that the northern part of the Boston basin was then occupied by the still little-decayed ice-sheet, an arm of which extended up the Neponset valley as far as Norwood.

PLAINS OF OTHER LEVELS.

Cedar Hill lakelet.—There still remain to be mentioned several important plains at levels different from any heretofore described. One of these plains occurs on the divide between Noanet and Mine Brooks in Dover. It lies at an elevation of 270 feet, and has a tributary esker on the north and frontal slopes on the south. Beginning a short distance south of the plain, and extending to beyond Walpole, a distance of over four miles, is one of the finest eskers in the region, supposed to mark the course of the stream through which this lakelet discharged.

Dedham plains.—In the towns of Dedham and Westwood are several plains having an elevation of about 120 feet. These are flat-topped, are either entirely or nearly surrounded by ice-contacts, have abundant kettles, and are not known to correspond with plains of any other group. Along the valley of the Charles River, between Dedham and South Natick, are a number of plains at elevations of 100 to 120 feet, which may belong to the same stage. Below this elevation all the plains are confined to the Lake Shawmut area, the western limit of which is marked by flat 90-foot deposits north of the ice-contact at Riverside and Newton Lower Falls, and which extend eastward throughout the Boston basin, where they are recognized at all elevations down to sea-level.

HISTORY OF THE LAKELETS.

The highest known plain in the region, the Cedar Hill plain, has an elevation of 100 feet above the next lower level, and must have been formed at the time of the earliest uncovering of the pass in the Dover highlands, which left a lake irregular in shape covering an area of nearly one square mile, walled on the east and west by rocky hills, and on the north and south largely by ice. The eskers in the valleys of Noanet and Mine Brooks suggest that this is another instance of a glacial lake having both inflowing and outflowing streams.

The occurrence of so numerous and widely scattered sandplains having a uniform elevation, which, notwithstanding their wide distribution, were evidently formed in merely local lakelets, often resting in part on the ice itself, is best explained by the assumption that the ice was in such a state of decay as to allow a connection between the individual lakelets sufficient to maintain the water at a common level. Such being the case, the general level of the waters at the different stages must have been determined by one of two causes; either, first, by deposition in an arm of the sea, or, second, as was more probable, by topographic features, probably passes between the highlands on the east side of the lower Neponset valley, through which the water escaped to Lake Bouvé,[1] and thence to the sea. The probable explanation for the lack of plains between the 270- and 170-foot levels is the absence of any pass intermediate between these elevations on the northern side of the Blue Hill range. In the southern portion of Lakes Charles and Neponset, where passes of other levels occur, intermediate plains also abound. The relations of ice, land, and water during the 170–150 foot stage are shown in Fig. 2.

This stage of the lakelets existed during the entire time while the outlets remained at this elevation. When the decay of the ice had advanced sufficiently to open a 120-foot outlet north of the Blue Hills, the ponded waters fell to that level. There is no indication that during this time there was any considerable disappearance of the ice in the upper and central portions of the Charles River basin, for in these portions no plains are known below 160 feet. The absence of synchronous plains in the Lake Shawmut area indicates that this was still for the most part ice. By far the greater portion of the 120-foot plains is situated in the town of Dedham, their location being probably due to their favorable position at the head of the Charles River valley glacier. Another view of their origin is that they represent merely a local stage, while the greater portion of the waters stood at a lower level.

[1] A. W. GRABAU, "Lake Bouvé," *Occ. Papers, Boston Society of Natural History*, Vol. IV, part III, pp. 564–600.

CONCLUSIONS.

The most important generalizations to be drawn from this study are as follows:

1. The decay of the ice *in situ* for many miles back from the ice-front—the decaying glacier consisting of a mass of stagnant ice overlain and buried by sheets of water and by extensive deposits of sand and gravel.

2. The more rapid disappearance of the ice on the west than farther east, causing a nearly open lake in parts of the Sudbury valley, while as yet the ice in the lower portions of the Boston basin had not decayed sufficiently to allow the formation of a single sand plain.

3. The interdependence of the water levels of the individual lakelets belonging to each stage, and their correspondence with some common outlet toward the sea.

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